

THE ADULT MALE OF THE TROGLOBITIC OSTRACODE
SPELAEOECIA BERMUDENSIS ANGEL AND ILIFFE, 1987,
FROM AN ANCHIALINE CAVE IN BERMUDA
(CRUSTACEA: OSTRACODA: HALOCYPRIDOIDEA)

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Abstract.—The previously unknown adult male of *Spelaeoecia bermudensis* Angel & Iliffe, 1987, the type species of the monotypic genus *Spelaeoecia* Angel & Iliffe, 1987, is described and illustrated from a specimen collected in Wonderland Cave, Bermuda. The fifth limb bears a large sensory organ that is absent on the limbs of the adult female as well as the juvenile male, and has not been reported previously in the suborder Halocypridina. The rod-shaped posterior branch of the copulatory organ is not inside the canal of the broad anterior branch as in other genera of the superfamily Halocypridoidea. The separated anterior and posterior branches resemble those of the copulatory organ of adult males in the superfamily Thaumatoocypridoidea, which together with the Halocypridoidea form the suborder Halocypridina. A brief supplementary description is given of the adult female.

The species *Spelaeoecia bermudensis* was described by Angel & Iliffe (1987:545) from 56 specimens (22 adults, but 2 of the adults represented by carapaces only) collected in 8 anchialine caves in Bermuda. Angel & Iliffe (p. 552) stated, "The absence of males in the collections could indicate that the species breeds by parthenogenesis, but it seems more likely that breeding occurs in parts of the cave inaccessible to divers." Kornicker & Iliffe (1989) reported from 2 anchialine caves in Bermuda 10 additional specimens including 2 A-1 males, which they described briefly. They mentioned an adult male collected in Wonderland Cave, Bermuda, which was encountered too late to conveniently include in their paper. That male is described herein. It was collected along with one juvenile and nine adult females in a baited trap by Jan H. Stock in 1984. Angel & Iliffe (1987:tab. 2) reported three adults (two represented by carapaces only) from the same cave. Unless the ratio of adult females to males in the species is unusually high it seems likely, as suggested

by Angel & Iliffe (1987), that adult females are more widespread than adult males. Perhaps the adult male described herein was attracted from some distance by the bait in the trap, and trapping rather than netting may be a more efficient method for collecting males. A brief supplementary description is presented based on a study of the holotype.

Superorder Myodocopa Sars, 1866

Composition.—This superorder comprises the orders Myodocopida Sars, 1866, and Halocyprida Dana, 1853.

Order Halocyprida Dana, 1853

Composition.—This order comprises the suborders Cladocopina Sars, 1866, and Halocypridina Dana, 1853.

Suborder Halocypridina Dana, 1853

Composition.—This suborder comprises the superfamilies Halocypridoidea Dana,

1853, and Thaumatoocypridoidea Müller, 1906.

Superfamily Halocypridoidea
Dana, 1853

Composition.—This superfamily contains the family Halocyprididae Dana, 1853.

Family Halocyprididae Dana, 1853

Composition.—This family comprises the subfamilies Halocypridinae Dana, 1853, Conchoecinae Claus, 1891, Archiconchoecinae Poulsen, 1969, Euconchoecinae Poulsen, 1969, and Deeveyinae Kornicker & Iliffe, 1985.

Subfamily Deeveyinae
Kornicker & Iliffe, 1985

Composition.—The subfamily comprises the genera *Deeveya* Kornicker & Iliffe, 1985, and *Spelaeoecia* Angel & Iliffe, 1987.

Spelaeoecia Angel & Iliffe, 1987

Type species.—*Spelaeoecia bermudensis* Angel & Iliffe, 1987.

Composition.—The genus is monotypic.

Terminology.—The lettering of bristles on the first and second antennae is the same as for the genus *Deeveya* explained in Kornicker and Palmer (1987:610). On the eighth joint of the first antenna of *Deeveya* the base of the d-bristle is slightly more lateral than on *Spelaeoecia*. Therefore, it is proposed that the anterior bristle regardless of whether it is lateral or medial be designated the d-bristle; the definitely lateral bristle near

midwidth of the joint and posterior to the d-bristle and stouter than other bristles on the joint be designated the e-bristle; the definitely medial bristle near midwidth of the joint and with proximal part slightly angled ventrally be designated the f-bristle, and the posterior bristle that is lateral to the f-bristle and either slightly medial to, or at same level, as the e-bristle be designated the g-bristle (Fig. 2a). The e-bristle is the "principal bristle." The terminology of the sixth limb is that suggested by Angel & Iliffe (1987:551) in which the joint previously interpreted to be the first exopodial joint is now designated the basale, and a terminal dorsal process on that joint is now designated the endopodite.

Spelaeoecia bermudensis
Angel & Iliffe, 1987

Fig. 1–5

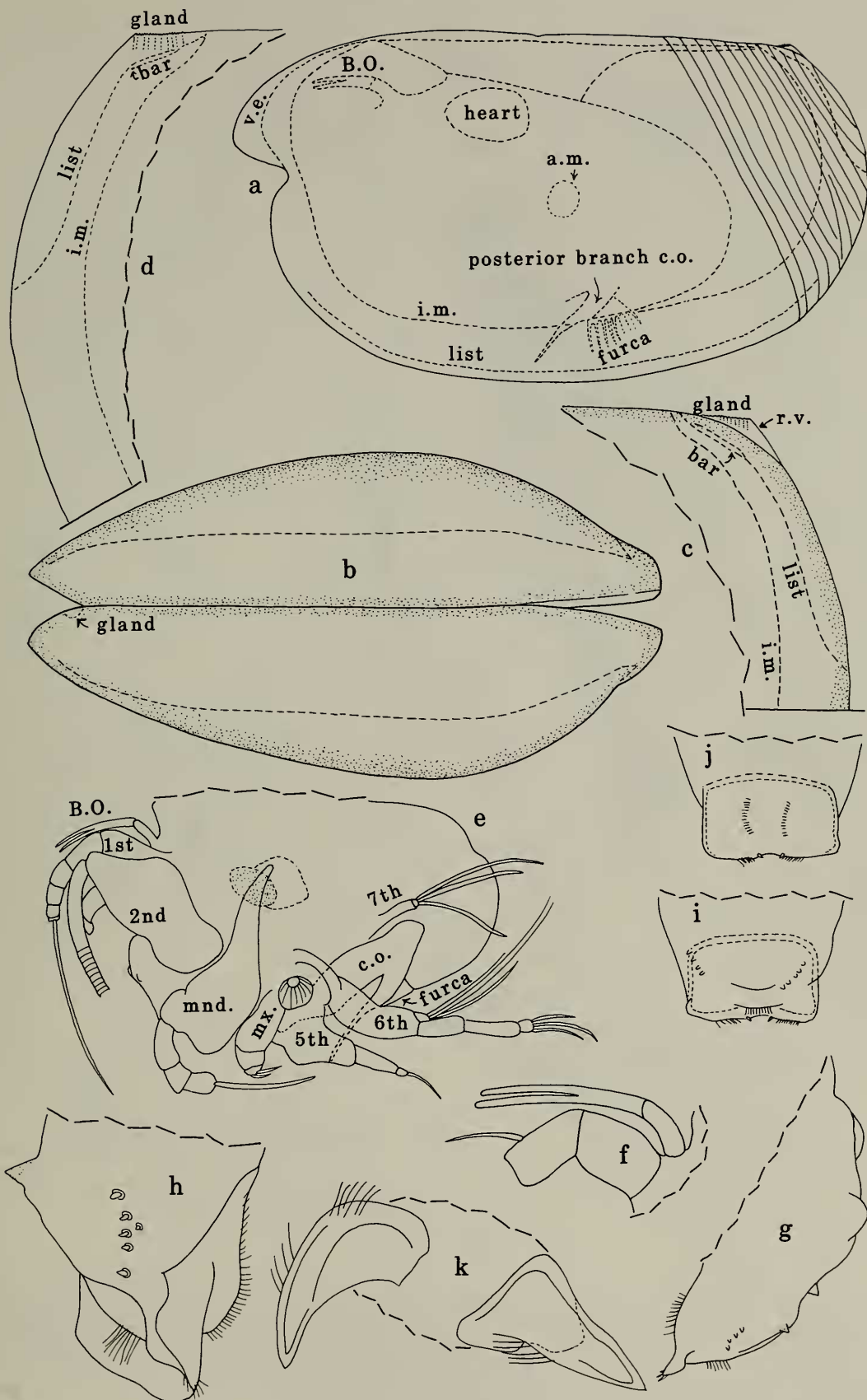
Spelaeoecia bermudensis Angel & Iliffe, 1987:545, figs. 2–6.—Kornicker & Iliffe, 1989, fig. 29.

Holotype.—USNM 228468, adult female on five slides.

Type locality.—Green Bay Cave, Bermuda.

Material.—Wonderland Cave, Bermuda: USNM 193483, one adult male on slide and in alcohol; USNM 193484A, one adult female in alcohol; USNM 193484B, one juvenile (length 1.27 mm, height 0.74 mm) plus nine adult females, all in alcohol; all collected 4 Oct 1984 in baited trap at 0–1 m depth by Dr. Jan H. Stock. Also examined: holotype, and 2 A-1 males (USNM 193404A, 193405A) from Jane's Cave, Ber-

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Fig. 1. *Spelaeoecia bermudensis*, adult male, USNM 193483: a, Lateral view of specimen from left side showing representative surface lineations and some internal characters, length 1.37 mm; b, Dorsal view of carapace with valves partly open (dashed lines indicate ventral edges of valves); c, Detail of posterodorsal corner of carapace, from "a"; d, Detail of posterior of right valve; e, Specimen showing relationship of appendages (Bellonci Organ, furca, copulatory organ, and appendages of left side; not all bristles of appendages shown); f, Bellonci Organ and joints 1 and 2 of left 2nd antenna; g, Anterior of body and upper lip from right side, anterior to right; h, Upper lip from left side, anterior to left; i, j, Upper lip, anterior and posterior views, respectively;



k, Ventral view of lower lip, anterior towards bottom. Abbreviations as follows: a.m. = adductor muscle attachment area of shell; B.O. = Bellonci Organ; c.o. = copulatory organ; endop. = endopodite; epip. = epipodite; exop. = exopodite; i.m. = inner margin of infold; mnd. = mandible; mx. = maxilla; r.v. = right valve; v.e. = valve edge. 1st = First antenna, 2nd = second antenna, 5th = fifth limb, 6th = sixth limb, 7th = seventh limb. Arabic numerals without a prefix refer to joints of endopodite or exopodite with 1 indicating proximal joint. Roman numerals identify endites with I indicating proximal endite.

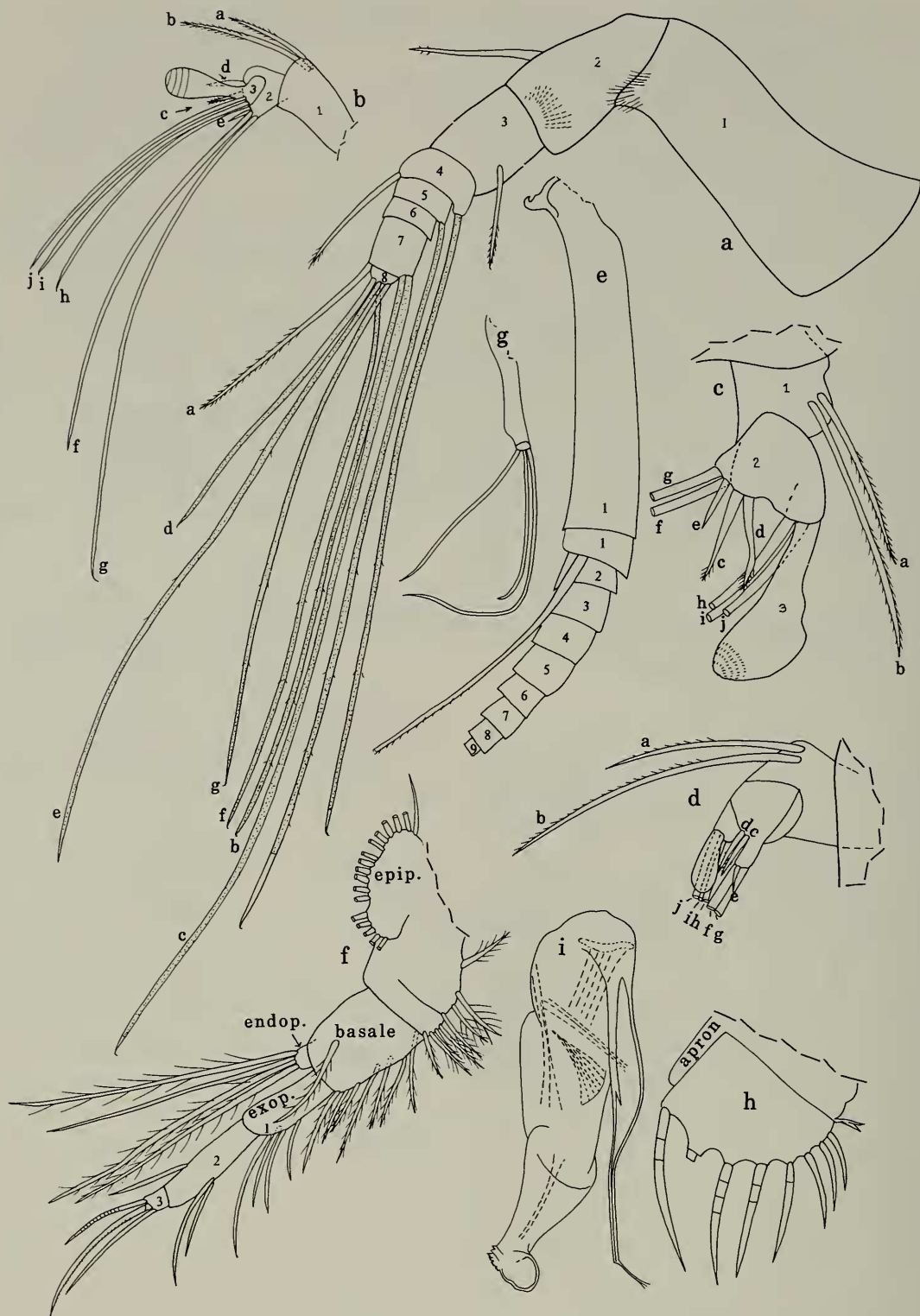
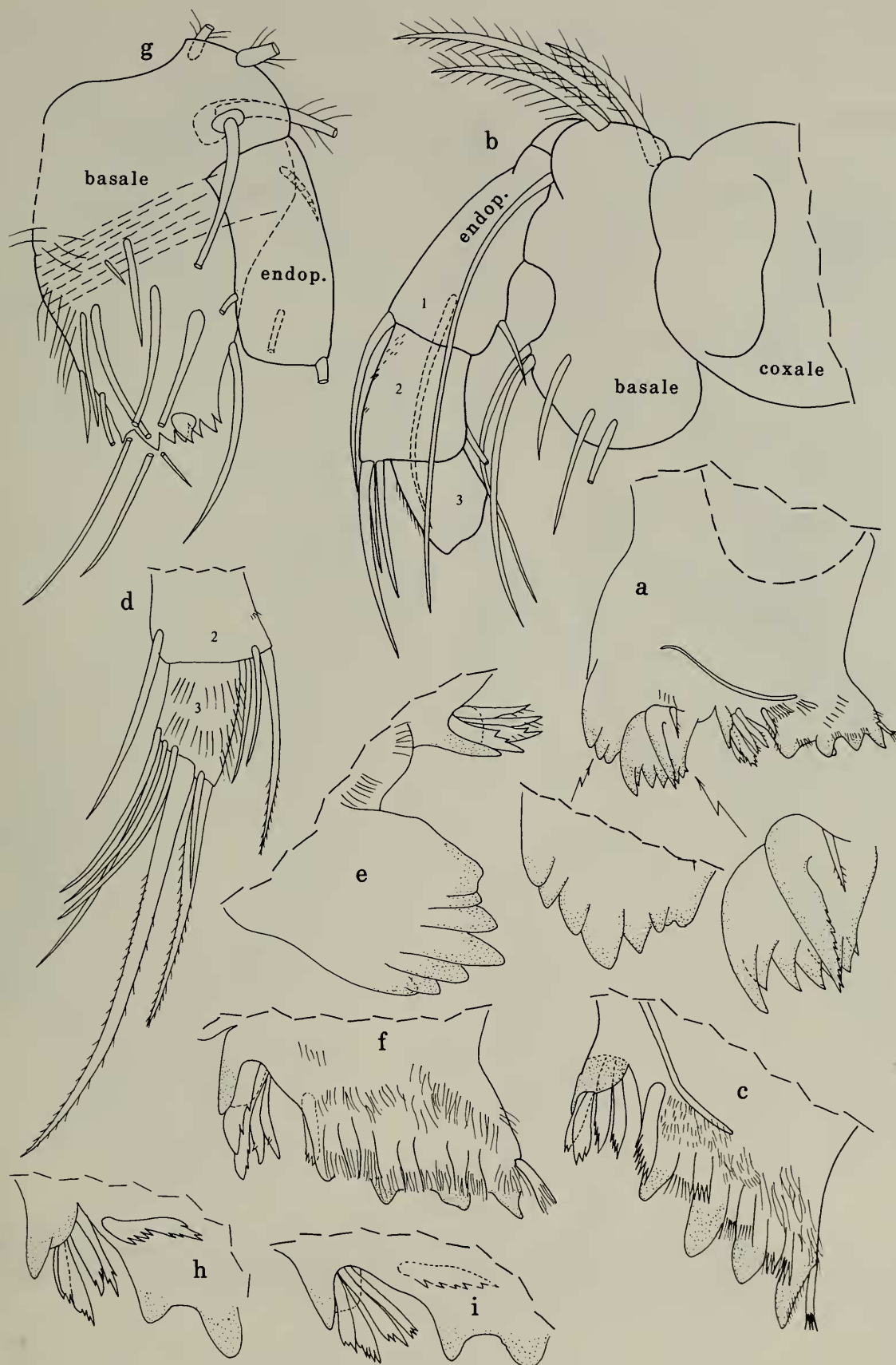


Fig. 2. *Spelaeoecia bermudensis*, adult male, USNM 193483: a, Left 1st antenna, lateral view; b, c, Endopodite of right 2nd antenna, medial and lateral views, respectively; d, Endopodite of left 2nd antenna, lateral view; e, Exopodite of 2nd antenna; f, Right 6th limb (only proximal part of all except dorsal epipodial bristles shown), lateral view; g, Left 7th limb, lateral view, ventral to left; h, Left lamella of furca, apron, and bifurcate unpaired bristle; i, Copulatory organ, anterior to left. For abbreviations, see Fig. 1.

Fig. 3. *Spelaeoecia bermudensis*, adult male, USNM 193483: a-d, Left mandible: a, Dorsal view of coxale endite, anterior to right; b, Lateral view of mandible (not all bristles of basale and none of 3rd endopodial joint



shown); c, Detail of proximal set of teeth of coxale endite, from "a"; d, Joints 2 and 3 of endopodite, medial view. e-g, Right mandible: e, Ventral view of outer distal set of teeth and part of proximal teeth of coxale endite (inner distal set not shown), anterior to right; f, Ventral view of proximal set of teeth, anterior to right; g, Lateral view of basale and joint 1 of endopodite, lateral view. Adult female, holotype, USNM 228468: h, i, bristles between proximal and distal sets of teeth of coxale endite: h, Ventral view of endite of right limb, anterior to right; i, Dorsal view of endite of left limb, anterior to right. For abbreviations, see Fig. 1.

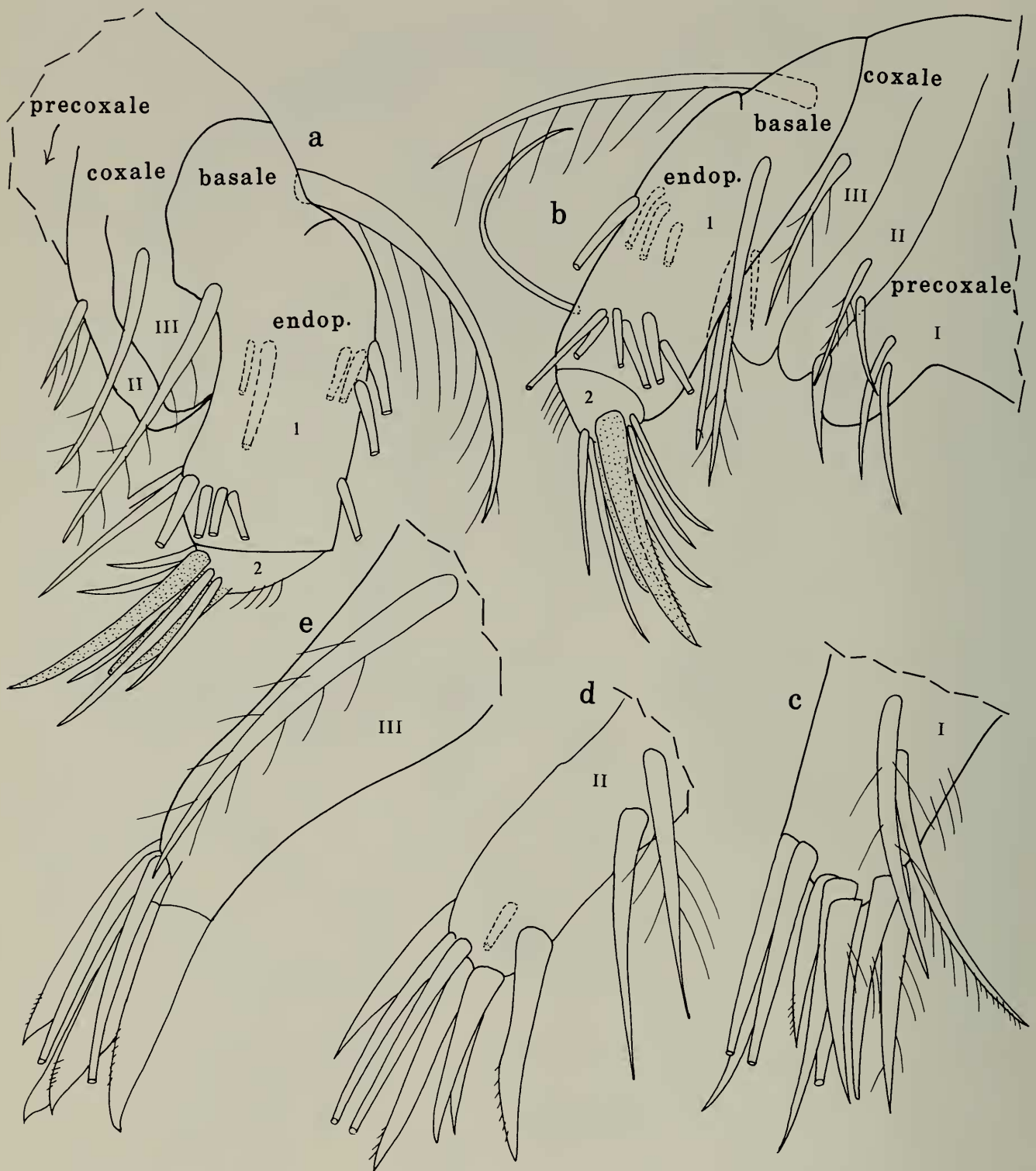
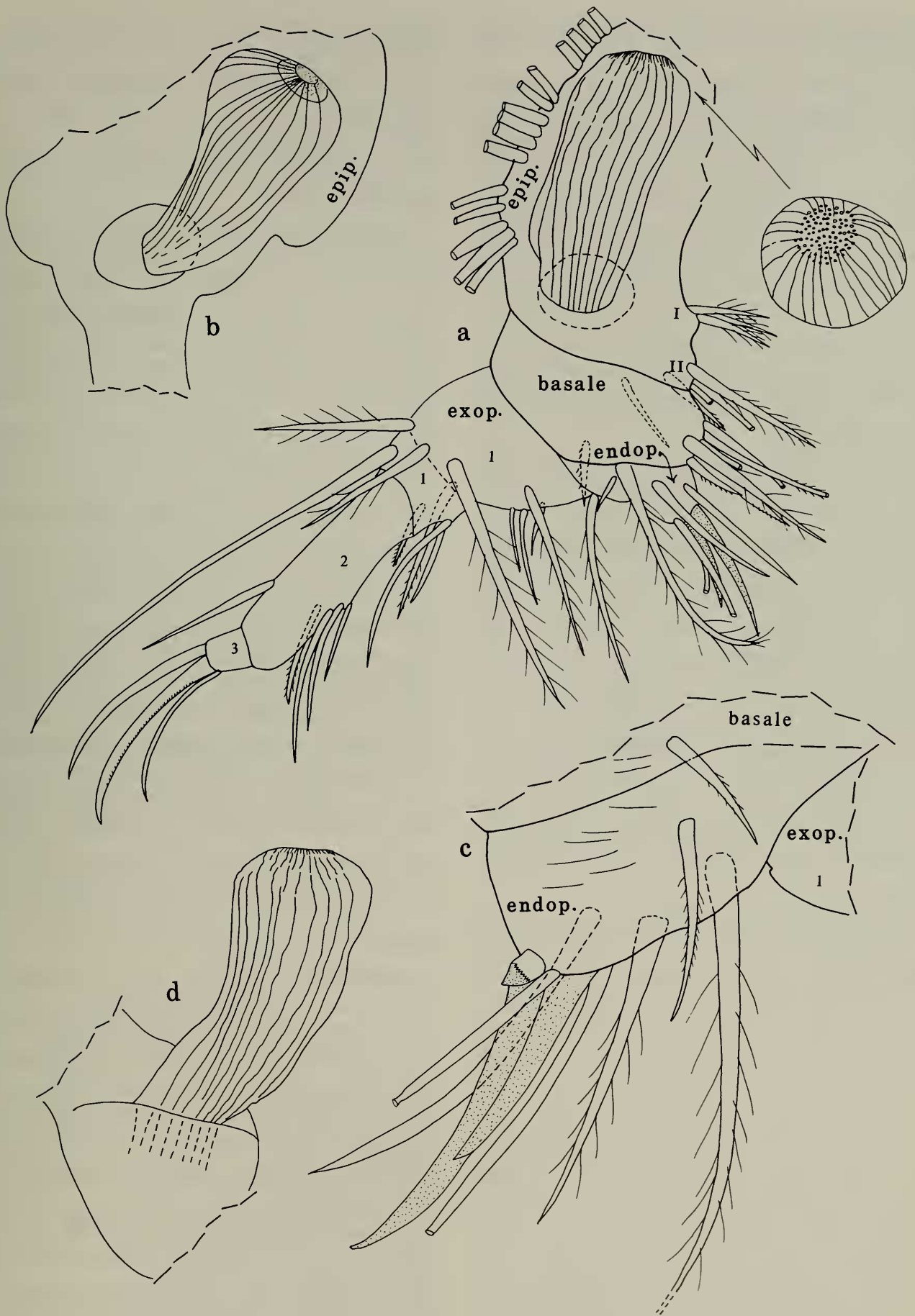


Fig. 4. *Spelaeoecia bermudensis*, adult male, USNM 193483, maxilla: a, Right limb (bristles of endites not shown); b, Left limb (not all endite bristles shown); c-e, Endites I-III of left limb (only proximal part of dashed bristle of endite II shown). For abbreviations, see Fig. 1.

Fig. 5. *Spelaeoecia bermudensis*, adult male, USNM 193483, 5th limb: a, Lateral view of right limb (only proximal part of epipodial bristles shown); b, Lateral view of sensory organ of protopodite of left limb, anterior to left (epipodial bristles not shown); c, Medial view of endopodite of right limb, anterior to left; d, Ventral



oblique view of sensory organ of protopodite of right limb, distal end of limb to lower right. For abbreviations, see Fig. 1.

muda, both discussed in Kornicker & Iliffe (1989).

Description of adult male (Figs. 1–3g, 4, 5).—Carapace uncalcified, elongate; dorsal margin straight, ventral margin broadly convex; anterior incisur just dorsal to midheight (Fig. 1a); in dorsal view carapace broadest near middle and narrowing posteriorly (Fig. 1b). Anterior edge of valve sinuate and posterior to anterior end of rostrum.

Ornamentation: Surface with thin lineations (representative lineations near posterior of left valve illustrated in Fig. 1a), and few single hairs.

Infold: Broad infold except along hinge, narrower just posterior to inner end of incisur (Fig. 1a). Narrow list distal to midwidth of infold extending from anteroventral to posteroventral corners of valve (Fig. 1a); a second list forming narrow bar posterior to posterior juncture of hinge, then extending ventrally as narrow list intersecting posterior edge of valve at midheight (Fig. 1c, d); at intersection second list joins lamellar prolongation of selvage suggesting that second list represents edge of valve and that segment of shell posterior to list is outer valve surface and similar in nature to outer surface of valve forming inner side of rostrum.

Glands (Fig. 1a–d): Posteroventral corner of right valve with about 10 minute glandular pores along dorsal edge. In lateral view posterodorsal corner (part bearing glands) of right valve extending dorsally past more rounded corner of left valve (Fig. 1c). Outer edge of that part of infold extending from incisur to midheight of posterior end of valve with about 18 minute broad tube-like glandular openings, mostly along anteroventral margin and anterior three-fourths of ventral margin (last opening just ventral to intersection of valve margin and second list); minute bristles along valve edge, generally one or two between adjacent tube-like glandular openings.

Selvage: With narrow unfringed prolon-

gation extending from inner corner of incisur to midheight of posterior end of each valve. Posterior end of prolongation ends at intersection between valve edge and ventral end of second list.

Size: USNM 193483, length 1.37 mm, height 0.78 mm.

First antenna (Figs. 1e, f, 2a): With eight distinct joints (Fig. 2a). First joint with terminal ventral extension with long spines. Second joint with distinct dorsal bristle with indistinct rings; medial surface of joint with distal spines. Third joint with ventral bristle with base on lateral surface. Fourth joint about half length of third, with dorsal bristle reaching past eighth joint, and very long ventral bristle. Fifth joint shorter than fourth, with long ventral bristle about three-times length of a-bristle of seventh joint. Sixth joint about same length as fifth joint, bare. Seventh joint longer than sixth, with short spinous a-bristle, long ventral b-bristle, and longer ventral c-bristle. Eighth joint with d-bristle anterior and slightly medial to e-bristle and about $\frac{1}{3}$ longer than a-bristle of seventh joint; e-bristle about twice length of d-bristle with indistinct proximal rings, f-bristle medial, bent ventrally, slightly shorter and narrower than e-bristle, g-bristle about same length as f-bristle. Long bristles of fourth, fifth, seventh, and eighth joints with indistinct minute marginal spines and longer terminal spine.

Second antenna (Figs. 1e, 2b–e): Protopodite bare (Fig. 1e). Endopodite three-jointed (Fig. 2b–d): First joint elongate with two slender spinous a- and b-bristles (a-bristle about two-thirds length of b-bristle); second joint with short c- and d-bristles with distal spines, one short lateral e-bristle, one long f-bristle, and one long g-bristle (g-bristle longer, stouter, and medial to f-bristle); third joint with long equilength h-, i-, and j-bristles, and terminal club-like process (process of right limb longer and stouter than that of left limb); long bristles of second and third joints with terminal papilla. Exopodite with nine joints (Figs. 1e, 2e): First joint

divided into long proximal and short distal segments (well developed separation of segments in sclerotized dorsal (concave) edge but not in ventral (convex) edge), and with long terminal bristle (with minute ventral spines) reaching well past ninth joint; bristles of joints two to eight stouter than bristle of first joint and with natatory hairs; ninth joint with four bristles (1 minute bare, one short with slender ventral spines, two long with natatory hairs).

Mandible (Figs. 1e, 3a–g): Coxale endite with proximal and distal sets of teeth separated by space (Fig. 3a–c, e, f): proximal set comprising four stout cusps and with indistinct spinous bristle at each end; surface between cusps and proximal to cusps with slender spines; stout tooth and four spinous bristles between proximal and distal sets of teeth. Distal set of teeth comprising two flat teeth, each with seven cusps; one stout curved process and one small bristle proximal to flat teeth. Basale (Fig. 3b, g): distal edge with five terminal triangular cusps, one sharper triangular anterior cusp, and a smaller posterior cusp; lateral surface near distal edge with sharp tooth near midwidth; lateral surface at or distal to midlength with one small bristle and five longer bristles; anterior margin with one long bristle distal to midlength; posterior margin hirsute, with two distal ringed bristles (proximal with slender tip, distal tubeformed); proximal medial surface with transparent plumose bristle on protuberance, and one short bristle near endopodite (Fig. 3g); two transparent plumose bristles present on or close to dorsal margin; lateral surface near insertion of endopodite with one long bare bristle. Endopodite (Figs. 1e, 3b, d, g): First joint with three bristles (one short, ventral, one long, medial, and one long, terminal, dorsal); second joint widening distally, with three terminal dorsal bristles (one claw-like, unringed, two ringed), one long unringed subterminal ventral bristle, and minute spines on dorsal margin and lateral surface near dorsal margin; third joint with two long

stout claw-like spinous terminal bristles, four short ringed bristles forming medial row along terminal edge, and one longer ringed bristle on terminal lateral edge; anterior margin and medial surface of third joint hirsute.

Maxilla (Figs. 1e, 4): Endite I with two proximal and nine terminal bristles (three tubeformed) (Fig. 4c); endite II with two proximal and eight terminal bristles (two tubeformed) (Fig. 4d); endite III with one long proximal bristle and six terminal bristles (two tubeformed) (Fig. 4e); some bristles on each endite stout pectinate. Basale with long stout dorsal bristle with long marginal spines and one long ventral bristle with long marginal spines (Fig. 4a, b); division of basale and first endopodial joint indicated only by separation at dorsal edge, elsewhere joints appearing fused. Endopodite (Fig. 4a, b): First joint with five anterior bristles (four proximal, one distal), two proximal bristles near posterior margin, and six distal bristles on or near posterior margin (because of orientation of limb on slide, the six distal bristles of the illustrated left maxilla are not close to the posterior margin); end joint with two stout claw-like bristles and five slender ringed bristles, and hairs along surface anterior to claws and bristles.

Fifth limb (Figs. 1e, 5): Epipodite with bristles forming three groups, each with four (dorsal group), six, and five plumose bristles (Fig. 5a). Protopodite with long striate sensory organ with many minute papillae at tip, and two endites (Fig. 5a, b, d): endite I with three bristles with long spines; endite II with four bristles (two with spines, two tubeformed). Basale with medial hairs, one long anterior bristle with long spines, two proximal medial bristles with short spines, and six ventral bristles (two pectinate claw-like, three tubeformed and either bare or with short spines, one with long spines) (Fig. 5a). Endopodite with medial hairs, one proximal medial bristle (with short spines) and eight additional bristles (one short tooth-like medial, two tubeformed, two claw-like,

two plumose, one long bare lateral) (Fig. 5a, c). First exopodial joint weakly divided into broad proximal and narrower distal parts (Fig. 5a): proximal part with eight bristles (three slender bare ventral bristles, one long plumose lateral bristle near ventral margin, one spinous medial distal bristle near ventral margin, one very long lateral plumose distal bristle at midheight of joint, one spinous lateral bristle near dorsal margin, and one spinous distal dorsal bristle); distal part with four bristles (one long subterminal bare dorsal bristle and three shorter bristles on or near ventral margin). Second exopodial joint: dorsal margin with one bare distal bristle; ventral margin with four slender bristles (bare or with short marginal spines) at midlength. Third exopodial joint with two stout claw-like unringed bristles (longer with indistinct minute ventral spines, other bare) and one slender bare ringed ventral bristle.

Sixth limb (Figs. 1e, 2f): Epipodite with bristles forming three groups, each with six, six, and five plumose bristles (Fig. 2f). Protopodite separated from basale by distinct suture and separated into two shallow lobes by ventral indentation and suture not reaching dorsal margin: proximal part with four ventral bristles, all with long spines; distal part with five bristles (four with long spines, one with short spines). Basale with six plumose bristles on or near ventral margin, and one distal lateral bristle at about midwidth of joint. Endopodite single-jointed with four long bristles (three with long spines, one bare). Exopodite three-jointed: first joint with four bare ventral bristles; second joint with three bare bristles (two ventral, one dorsal); third joint with three bristles (middle bristle claw-like with short ventral spines, dorsal bristle bare, tending to be claw-like, with oblique rings, ventral bristle bare). Protopodite and basale with long medial hairs.

Seventh limb (Figs. 1e, 2g): Elongate with three long terminal bristles.

Furca (Figs. 1e, 2h): Each lamella with

eight claws; claw 1 with two weak transverse sutures, claw 3 with three, claw 4 with two, claw 5 with one; claw 2 broken off near base; left lamella slightly anterior to right. Unpaired bristle bifurcate.

Bellonci organ (Fig. 1e, f): Elongate with suture at proximal third, bifurcating at about two-thirds length; each branch with rounded tip just reaching third joint of first antenna.

Lips (Fig. 1g–k): Anterior face with two small triangular processes (one on each side) and small glandular processes forming row on each side (four–six processes in each row) (Fig. 1g–i). Terminal posterior edge with a minute spine-like process and slender spines at each side of shallow median concavity (Fig. 1h, i). Lower lip with triangular process on each side of mouth (Fig. 1k).

Copulatory organ (Figs. 1e, 2i): On left side of body and consisting of two parts: posterior rod-shaped organ with very long styliform process with hirsute tip; anterior part broad with slight knee-like bend at about distal two-thirds and terminating in foot-shaped process with rows of minute teeth in “heel” area.

Apron (Fig. 2h): Reaching about three-fourths length of anterior margin of furcal lamellae.

Supplementary description of adult female (Fig. 3h, i).—Size (mm): USNM 193484A, length 1.52, height 0.86; USNM 193484B, six specimens (length:height): 1.54:0.91, 1.49:0.85, 1.49:0.82, 1.43:0.83, 1.53:0.85, 1.46:0.83. Range: length 1.43–1.52 mm, height 0.82–0.91 mm. Because some specimens were measured with valves slightly open, height measurement is less accurate than that of length. (Angel & Iliffe (1987:545) gave the dimensions of three females: range of lengths 1.58–1.64 mm. They also presented (Fig. 7) a shell length-width graph with dimensions of 21 females having a length range of about 1.41–1.64 mm. Kornicker & Iliffe (1989) gave the dimensions of two females with lengths of 1.54 mm and

1.57 mm. The lengths of the females in the present collection fall within the range of previous collections.)

First antenna: Ventral bristle of fourth joint about same length as a-bristle of seventh joint; limb otherwise similar to that of adult male.

Mandible (Fig. 3h, i): Similar to that of male. The exact number of bristles adjacent to the stout tooth between proximal and distal sets of teeth of the coxale endite is difficult to resolve; it is interpreted to be four herein (Fig. 3h, i), but could be only three. Angel & Iliffe (1987:547, fig. 4B) in describing the coxale stated, "Between outer and middle list single long curved spine." The spine is present on one limb of the holotype but not on the other, and examination of the "spine" under oil immersion revealed it to be debris.

Sexual dimorphism.—The carapace of the single adult male (length 1.37 mm) is shorter than known females (range of length 1.41–1.64 mm). The ventral bristle of the fourth joint of the first antenna is about the same length as the a-bristle of the seventh joint on the adult female and almost three-times the length on the adult male. The fifth limb of the adult male bears a well developed sensory organ not previously reported in the halocyprids. The fifth limbs of two adult females (Holotype and USNM 193484A) and 2 A-1 males (USNM 193404A, 193405A) were examined and found not to have a sensory organ; the A-1 males are from Jane's Cave, Bermuda, and were discussed in Kornicker & Iliffe (1989).

Discussion.—Although classed in the Halocypridoidea, the Deeveyinae in many nonsexual characters appear to be a link between the Thaumatoocypridoidea and Halocypridoidea. This relationship is also evident when comparing the copulatory organs of adult males in the two superfamilies. The copulatory organ of the adult male *S. bermudensis* has the rod-shaped process sep-

arate from the broader anterior lobe, similar to the copulatory organ of thaumatoocyprids. In halocyprids other than *S. bermudensis* the rod-shaped process of the adult male lies inside a canal within the anterior lobe. Juvenile males of both thaumatoocyprids and halocyprids have the rod-shaped process separate from the anterior lobe suggesting that having the rod-shaped process inside a canal within the anterior lobe is an apomorphic character state. The endopodite of the adult male second antenna of *S. bermudensis* differs from those generally present in both thaumatoocyprids and halocyprids in having a straight rather than hook-shaped clasper. Not all halocyprids have a clasper.

Acknowledgments

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